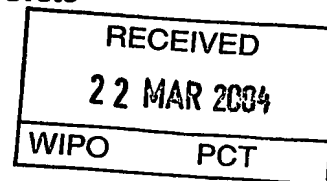




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Process for treating an organic solution comprising cyclohexanone, and an organic solvent

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s)
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4416 PE

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PROCESS FOR TREATING AN ORGANIC SOLUTION COMPRISING
CYCLOHEXANONE OXIME, CYCLOHEXANONE, AND AN ORGANIC SOLVENT

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The invention relates to a process for treating an organic solution comprising cyclohexanone oxime, cyclohexanone and an organic solvent.

Oximes can be produced in a process in which a buffered, aqueous reaction medium containing buffer acids or acidic salts, for example phosphate buffers, and buffer salts derived from these acids, is continuously recycled between a hydroxylammonium synthesis zone and an cyclohexanone oxime synthesis zone. In the hydroxylammonium synthesis zone hydroxylammonium may be formed by catalytic reduction of nitrate ions or nitric oxide with hydrogen. In the cyclohexanone oxime synthesis zone, hydroxylammonium formed in the hydroxylammonium synthesis zone may react with cyclohexanone to form cyclohexanone oxime. The cyclohexanone oxime can then be separated from the aqueous reaction medium which is recycled to the hydroxylammonium synthesis zone.

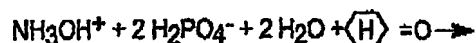
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The net chemical reactions occurring during the process can be represented by the following equations:

1) Preparation of the hydroxylammonium:

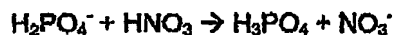


25 2) Preparation of the oxime



3) Supply of HNO_3 to make up the depletion of the source of nitrate ions after removal of the oxime formed

30



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In the cyclohexanone oxime synthesis zone, cyclohexanone oxime may be prepared by countercurrently contacting an aqueous medium comprising hydroxylammonium in water with an organic medium comprising cyclohexanone dissolved in an organic solvent, e.g. toluene or benzene. An organic solution comprising the formed cyclohexanone oxime dissolved in organic solvent may be withdrawn from the reaction zone, and distilled to recover cyclohexanone oxime.

GB-A-1,138,750 discloses a process, wherein the conversion of cyclohexanone in the cyclohexanone oxime synthesis zone is incomplete, resulting in an organic solution comprising, besides cyclohexanone oxime and organic solvent, cyclohexanone. In said process the organic solution containing the residual cyclohexanone is fed to an after-reaction vessel to convert the residual cyclohexanone into cyclohexanone oxime by reaction with hydroxylammonium at an increased pH. After the conversion of the residual cyclohexanone in the after-reaction vessel, the organic solution is subjected to the distillation to recover the cyclohexanone oxime. This process is disadvantageous, since the after-reaction results in salt formation.

EP-A-5291 also describes a process wherein the conversion of cyclohexanone is incomplete, resulting in an organic solution comprising, cyclohexanone oxime, organic solvent (toluene) and cyclohexanone. In order to obviate the conversion of cyclohexanone in the after-reaction vessel, EP-A-5291 provides a process, wherein the cyclohexanone-containing organic solution is subjected to distillation. In a first step organic solvent is separated out as a (first) top product. The resulting bottom product is further distilled to obtain cyclohexanone oxime as a bottom product. As a result of this further distillation a (second) top product is obtained comprising cyclohexanone and organic solvent. Accordingly, the process of EP-A-5291 results in a first product comprising organic solvent, a second product comprising cyclohexanone, and a third product comprising cyclohexanone oxime.

In the process of EP-A-5291, the second product comprising cyclohexanone is not further used or treated. The distillation is carried out extensively, e.g. using a reflux or a three-column system, apparently to separate out as much of the cyclohexanone oxime as possible. Such extensive distillation has the disadvantage that it requires high investment and/or operational costs.

Goal of the invention is to provide a simple process wherein such extensive distillation and complete separation of cyclohexanone oxime is not necessary.

This goal is achieved according to the invention by providing a process for treating an organic solution comprising cyclohexanone oxime,

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cyclohexanone and an organic solvent, said process comprising distilling the organic solution to obtain (i) a first product comprising organic solvent, (ii) a second product comprising cyclohexanone and (iii) a third product comprising cyclohexanone oxime; and feeding the second product to a cyclohexanone oxime synthesis zone in which
5 hydroxylammonium is reacted with cyclohexanone to form cyclohexanone oxime.

According to the invention a simple process is provided wherein extensive distillation is not necessary. Cyclohexanone oxime can be allowed in the second product, and can advantageously be recovered from the cyclohexanone oxime synthesis zone, preferably in a solution containing the cyclohexanone oxime formed in
10 the cyclohexanone oxime-synthesis zone.

According to the invention, the second product is fed into a cyclohexanone oxime synthesis zone. In the cyclohexanone oxime synthesis zone, hydroxylammonium is reacted with cyclohexanone to form cyclohexanone oxime. There are various ways to operate the cyclohexanone oxime synthesis zone. In a
15 preferred embodiment an aqueous medium comprising hydroxylammonium in water, and an organic medium comprising cyclohexanone in organic solvent, are, preferably countercurrently, contacted in the cyclohexanone oxime synthesis zone.

A more preferred embodiment for operating the cyclohexanone oxime synthesis zone is process comprising countercurrently contacting an aqueous medium
20 with an organic medium in said cyclohexanone oxime synthesis zone, said aqueous medium containing hydroxylammonium, said organic medium comprising organic solvent and cyclohexanone; feeding organic solvent into said cyclohexanone oxime synthesis zone at a feeding level for organic solvent; feeding cyclohexanone into said cyclohexanone oxime at a feeding level for cyclohexanone, said feeding level for
25 cyclohexanone preferably being downstream of the feeding level for organic solvent (seen in the flow direction of the organic medium); and discharging an organic product solution comprising cyclohexanone oxime, and organic solvent from the cyclohexanone oxime synthesis zone at a discharge level for organic product solution, said discharge level for organic product solution being downstream of the feeding level for
30 cyclohexanone (seen in the flow direction of the organic medium).

As used herein, feeding level for organic solvent refers to the level at which organic solvent is fed into the cyclohexanone oxime synthesis zone. Feeding level for cyclohexanone refers to the level at which cyclohexanone is fed into the cyclohexanone oxime synthesis zone. Discharge level for organic product solution
35 refers to the level at which organic product solution is discharged from the

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cyclohexanone oxime synthesis zone. As used herein downstream and upstream are defined for the situation as seen in the flow direction of the organic medium.

As a cyclohexanone oxime synthesis zone any suitable
countercurrent contact zone may be used in which the aqueous medium and organic
5 medium are countercurrently contacted. The cyclohexanone oxime synthesis zone may
comprise a first contact zone, in which the aqueous medium and the organic medium
between the feeding level for cyclohexanone and the discharge level for organic
product solution are countercurrently contacted. As used herein the aqueous medium
and the organic medium between the feeding level for cyclohexanone and the
10 discharge level for organic product solution refers to the aqueous medium and the
organic medium downstream of the feeding level for cyclohexanone and upstream of
the discharge level for organic product solution (seen in the flow direction of organic
medium). As a first contact zone may be used any suitable type of counterflow
reactors, for instance an extraction column, preferably a pulsed packed column or
15 rotating disc reactors. It is also possible to use as a first contact zone a system
comprising a number, preferably at least 3, e.g. 3 to 6, series-connected reactors
equipped with stirrers, each of these reactors also being provided with a liquid-liquid
separator. These may also be referred to as mixer-settlers. The cyclohexanone oxime
synthesis zone may also comprise a second contact zone, in which the aqueous
20 medium and the organic medium between the feeding level for organic solvent and the
feeding level for cyclohexanone are countercurrently contacted. As used herein the
aqueous medium and organic medium between the feeding level for organic solvent
and the feeding level for cyclohexanone refers to the aqueous medium and the organic
medium downstream of the feeding level for organic solvent and upstream of the
25 feeding level for cyclohexanone (seen in the flow direction of the organic medium). As
a second contact zone may be used any suitable type of counterflow reactors, for
instance an extraction column, preferably a pulsed packed column or rotating disc
reactors. It is also possible to use as a second contact zone a system comprising a
number, preferably at least 3, e.g. 3 to 6, series-connected reactors equipped with
30 stirrers, each of these reactors also being provided with a liquid-liquid separator.

The cyclohexanone oxime synthesis zone is preferably operated at a
temperature between 40 to 150 °C.

We found preferred levels for feeding the second product into the
cyclohexanone oxime synthesis zone. The preferred levels result in decreased
35 concentrations of organic compounds, in particular of cyclohexanone and

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cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone. A low sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone has the advantage that, when the aqueous medium is recycled to a hydroxylammonium synthesis zone, the extent of catalyst poisoning in the hydroxylammonium synthesis zone decreases and/or that separation steps for removing said cyclohexanone oxime and/or cyclohexanone from the aqueous medium prior to recycling to a hydroxylammonium synthesis zone can be omitted and/or carried out to a lesser extent. Preferably, the process comprises feeding the second product to the cyclohexanone oxime synthesis such that the sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone contains less than 20,000 ppm (2 wt.%, relative to the weight of the aqueous medium), preferably less than 5,000 ppm (0.5 wt.%), more preferably less than 1,000 ppm (0.1 wt.%), more preferably less than 500 ppm (0.05 wt.%), more preferably less than 200 ppm (0.02 wt.%).

Preferably, the process according to the invention comprises countercurrently contacting an aqueous medium with an organic medium in said cyclohexanone oxime synthesis zone, said aqueous medium containing hydroxylammonium, said organic medium comprising organic solvent and cyclohexanone; feeding organic solvent into said cyclohexanone oxime synthesis zone at a feeding level for organic solvent; and feeding said second product into said cyclohexanone oxime synthesis zone at a level downstream of the feeding level for organic solvent (seen in the direction of flow of the organic medium). This is an advantageous embodiment for achieving a low sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone.

The invention also provides a process treating an organic product comprising cyclohexanone and cyclohexanone oxime, for instance a second product, said process comprising, in a hydroxylammonium synthesis zone, countercurrently contacting an aqueous medium with an organic medium, said aqueous medium containing hydroxylammonium, said organic medium comprising organic solvent and cyclohexanone, to form cyclohexanone oxime; feeding organic solvent into said cyclohexanone oxime synthesis zone at a feeding level for organic solvent; and feeding said organic product into said cyclohexanone oxime synthesis zone at a level downstream of the feeding level for organic solvent (seen in the direction of flow of the

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organic medium). This is an advantageous method for using an organic product comprising cyclohexanone and cyclohexanone oxime, while keeping a low sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone.

5 Preferably, the process according to the invention comprises: feeding cyclohexanone into the cyclohexanone oxime synthesis zone at a feeding level for cyclohexanone, said feeding level for cyclohexanone being downstream of the feeding level for organic solvent (seen in the direction of flow of the organic medium); and feeding the second product into the cyclohexanone oxime synthesis zone at the
10 feeding level for cyclohexanone or downstream of the feeding level for cyclohexanone (seen in the direction of flow of the organic medium). This embodiment has the advantage that the sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone is further decreased.

15 In a preferred embodiment, the process comprises: discharging an organic product solution comprising cyclohexanone oxime, organic solvent from said cyclohexanone oxime synthesis zone at discharge level for organic product solution, said discharge level for organic product solution being downstream of the feeding level for cyclohexanone (seen in the direction of flow of the organic medium); and feeding
20 the second product upstream of the discharge level for organic product solution. (seen in the direction of flow of the organic medium). This facilitates the reaction of the cyclohexanone supplied to the cyclohexanone oxime synthesis zone via the second product.

In a preferred embodiment, the aqueous medium and organic
25 medium present between the feeding level for cyclohexanone and the discharge level for organic product solution have a sum volume of V , the process comprising feeding the second product into the cyclohexanone oxime synthesis zone at a level such that the aqueous medium and the organic medium present between the feeding level for cyclohexanone and the level at which the second product is fed into cyclohexanone
30 oxime synthesis zone have a sum volume of at least $V/10$, preferably of at least $V/5$. This facilitates the decrease of the sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone. As used herein sum volume refers to the volume of the aqueous medium and the organic medium. Preferably, the process comprises feeding the
35 second product into the cyclohexanone oxime synthesis zone at a level such that the

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aqueous medium and the organic medium present between the feeding level for cyclohexanone and the level at which the second product is fed into cyclohexanone oxime synthesis zone have a sum volume of less than $9 \cdot V/10$, preferably of less than $4 \cdot V/5$. This facilitates the reaction of the cyclohexanone supplied to the cyclohexanone oxime synthesis zone via the second product.

5 In a preferred embodiment, the process comprises countercurrently contacting the aqueous medium and the organic medium present between the feeding level for cyclohexanone and discharge level for organic product solution in a column or in series-connected columns, said column or said series-connected columns having a
10 total column length L , and feeding the second product into said column or series-connected columns at a distance of at least $L/10$ measured from said feeding level for cyclohexanone. This facilitates the decrease of the sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the
15 cyclohexanone oxime synthesis zone. A used herein the total column length L refers to the column length if the aqueous medium and the organic medium between the feeding level for cyclohexanone and discharge level for organic product solution are contacted in one column, and to the sum length of columns of the series-connected
20 columns if the aqueous medium and the organic medium between the feeding level for cyclohexanone and discharge level for organic product solution are countercurrently contacted in series-connected columns. Preferably, the process comprises feeding the second product into the column or series-connected columns at a distance of less than $9 \cdot L/10$, more preferably a distance of less than $4 \cdot L/5$, measured from the feeding level for cyclohexanone. This facilitates the reaction of the cyclohexanone supplied to the cyclohexanone oxime synthesis zone via the second product.

25 In a preferred embodiment, the process comprises countercurrently contacting the aqueous medium and the organic medium present between the feeding level for cyclohexanone and discharge level for organic product solution in a number (m) of series-connected mixer-settlers; and feeding the second product into to the second or higher-numbered mixer-settler counted from the feeding level for
30 cyclohexanone. This facilitates the decrease of the sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone. Preferably, the process comprises feeding the second product to the m , $m-1$, or lower-numbered mixer-settler, counted from the feeding level for cyclohexanone. This facilitates the reaction of the cyclohexanone
35 supplied to the cyclohexanone oxime synthesis zone via the second product.

The organic solution which is treated according to the invention may be any organic solution comprising cyclohexanone oxime, cyclohexanone and an organic solvent. Preferably the process according to the invention comprises withdrawing the organic solution from a cyclohexanone oxime synthesis zone. More preferably, the process according to the invention comprises withdrawing the organic solution from the cyclohexanone oxime synthesis zone to which the second product is fed. The concentration of cyclohexanone in the organic solution may be higher than 0.1 wt.%, preferably higher than 0.5 wt.%, most preferably higher than 1 wt.%. The concentration of cyclohexanone in the organic solution may be lower than 10 wt.%, preferably lower than 5 wt.%. The concentration of cyclohexanone oxime in the organic solution may be higher than 5 wt.%, preferably higher than 10 wt.%, more preferably higher than 25 wt.%, and may be lower than 80 wt.%, preferably lower than 50 wt.%. The concentration of organic solvent in the organic solution may be higher than 40 wt.%, preferably higher than 50 wt.%, and may be lower than 95 wt.%, preferably lower than 90 wt.%. Preferably the organic solution is an organic product solution comprising organic solvent, cyclohexanone oxime and cyclohexanone, said organic product solution being discharged from a or from the cyclohexanone oxime synthesis zone, preferably at the discharge level for organic product solution. The preferred concentrations for the organic solvent, cyclohexanone oxime and cyclohexanone in the organic solution are also preferred concentrations for the organic product solution.

The distillation may be carried out in any suitable way. Preferably, the second product is obtained as a distillate (overhead product). Preferably, the process comprises distilling the organic solution to obtain the first product as a distillate; distilling the remaining bottom product to obtain the second product as a distillate and the third product as a bottom product.

The second top product may advantageously be fed to the cyclohexanone oxime synthesis zone.

Preferably, the distillation of the organic solution to obtain the first product as a distillate is carried out at a temperature of between 35 and 80 °C, more preferably between 50 and 70 °C. Preferably, the distillation to obtain the first product as a distillate is effected at a pressure of between 0.006 and 0.4 MPa and more preferably between 0.012 and 0.025 MPa. The first product may for instance comprise at least 98 wt.% of organic solvent, preferably at least 99 wt.% of organic solvent, more preferably at least 99.5 wt.% of organic solvent, most preferably at least 99.9 wt.% of organic solvent (with respect to the weight of the first product). The first product is

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preferably recycled to a or to the cyclohexanone oxime synthesis zone, preferably at the feeding level for organic solvent. Preferably, the distillation of the remaining bottom product to obtain the second product as a distillate and the third product as a bottom product is carried out at a temperature of between 70 and 115 °C, more preferably
5 between 85 and 100 °C. Preferably, the distillation of the remaining bottom product to obtain the second product as a distillate and the third product as a bottom product is carried out at a pressure of between 0.010 and 0.020 MPa. Preferably, the third product comprises at least 95 wt.% of cyclohexanone oxime, more preferably at least 98 wt.% of cyclohexanone oxime, most preferably at least 99 wt.% of cyclohexanone
10 oxime (with respect to the weight of the third product). As used herein, the temperature refers to the temperature in the top of a column in which the distillation is effected. As used herein, the pressure refers to the pressure in the top of a column in which the distillation is effected.

According to the invention a second product is obtained containing
15 cyclohexanone and which preferably also contains cyclohexanone oxime. Preferably, the weight ratio cyclohexanone oxime/cyclohexanone in the top product is higher than 0.1, preferably higher than 0.2, more preferably higher than 0.3, in particular higher than 0.4, more in particular higher than 0.5. An increased ratio has the advantage that the distillation can be effected in a simpler way. The ratio cyclohexanone
20 oxime/cyclohexanone in the top product is for instance less than 100. The second product may comprise organic solvent, for instance more than 10 wt.%, preferably more than 25 wt.%, more preferably more than 50 wt.%, for instance less than 95 wt.%, preferably less than 90 wt.%. Preferably, the sum concentration of cyclohexanone and cyclohexanone oxime in the top product is higher than 5 wt.%, more preferably higher
25 than 10 wt.%. Preferably, the sum concentration of cyclohexanone and cyclohexanone oxime in the second product is less than 75 wt.%, more preferably less than 50 wt.%. All weight percentages are given with respect to the weight of the second product.

The distillation may be carried out using any suitable column or combination of columns. Preferably, the distillation is carried out using two or three
30 columns, most preferably two columns. Preferably, the process comprises, preferably in a system comprising two columns, distilling the organic solution in a first column to obtain the first product as a distillate; and feeding the remaining bottom product to the top of a distillation column or to a column without a rectifying section. This is a simpler way of distilling which is made possible by the process according to the invention.

35 Any suitable aqueous medium containing hydroxyl ammonium may

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be fed to the cyclohexanone oxime synthesis zone. The concentration hydroxylammonium in the aqueous reaction medium entering (fed to) the cyclohexanone oxime synthesis zone may have any suitable value, for instance higher than 0.7 mol/l, preferably higher than 1.0 mol/l, and may be below 2.5 mol/l. We found that the process according to the invention has additional advantages in a preferred embodiment wherein the ratio $f_h/f_o < 1.00$, more preferably < 0.99 , more preferably less than 0.98, wherein f_h represents the molar quantity of hydroxylammonium fed to the cyclohexanone oxime synthesis zone per unit of time (in mol/s), and f_o represents the molar quantity of cyclohexanone fed to the cyclohexanone oxime synthesis zone per unit of time (in mol/s).

Decreasing this ratio has the advantage that the concentration organic compounds, in particular cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone is decreased. An organic product solution containing unconverted cyclohexanone may advantageously be treated by the process according to the invention. There is no specific lower limit for the ratio f_h/f_o . The ratio f_h/f_o is generally higher than 0.5, preferably higher than 0.7, more preferably higher than 0.8.

Preferably, the aqueous medium contains phosphate. Preferably, the aqueous medium is an acidic, buffered medium. The phosphate concentration in the aqueous medium entering (fed to) the cyclohexanone oxime synthesis zone is higher than 2.0 mol/l, preferably higher than 2.5 mol/l, more preferably higher than 3.0 mol/l, in particular higher than 3.3 mol/l, more in particular higher than 3.5 mol/l, most preferably higher than 3.7 mol/l. We have found that increasing the phosphate concentration in the aqueous medium entering the cyclohexanone oxime synthesis zone is advantageous, since it results in a decrease of the concentration of organic contaminants in the aqueous medium exiting the cyclohexanone oxime synthesis zone. The phosphate concentration in the aqueous medium entering the cyclohexanone oxime synthesis zone may be lower than 8 mol/l, preferably lower than 5 mol/l, more preferably lower than 4.5 mol/l. As used herein, the phosphate concentration denotes the sum concentration of all phosphates, irrespective of the form in which they are present, expressed in mol per liter of aqueous reaction medium. Preferably, the phosphates are present as PO_4^{3-} , HPO_4^{2-} , H_2PO_4^- , H_3PO_4 , salts of PO_4^{3-} , HPO_4^{2-} , H_2PO_4^- , and/or combinations thereof. The aqueous medium may contain ammonium (NH_4^+), for instance formed as a by-product in the synthesis of hydroxylammonium. Preferably, in the aqueous medium entering the cyclohexanone oxime synthesis zone,

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the ratio $c(\text{NH}_4^+)/c(\text{phosphate})$ is between 0.1 and 3, more preferably between 0.2 and 2, most preferably between 0.5 and 1.5, wherein $c(\text{NH}_4^+)$ represents the concentration of NH_4^+ in mol/l and $c(\text{phosphate})$ represents the phosphate concentration in mol/l. The aqueous medium entering the cyclohexanone oxime synthesis zone may contain

5 nitrate (NO_3^-). Preferably, in the aqueous medium entering the cyclohexanone oxime synthesis zone, the $c(\text{NO}_3^-)/c(\text{phosphate})$ is between 0.05 and 1, more preferably between 0.1 and 0.5, wherein $c(\text{NO}_3^-)$ represents the concentration of NO_3^- in mol/l and $c(\text{phosphate})$ represents the phosphate concentration in mol/l. Preferably, the aqueous medium which is fed to the cyclohexanone oxime synthesis zone has a pH of between

10 1 and 6, more preferably between 1.5 and 4.

The cyclohexanone oxime synthesis zone may be operated at a temperature ranging from 40 to 150°C and at atmospheric, sub-atmospheric, or elevated pressures, preferably between 0.05 and 0.5 MPa, more preferably between 0.1 and 0.2 MPa, most preferably between 0.1 and 0.15 MPa.

15 Any suitable organic solvent may be used. Preferably, the organic solvent is selected from the group consisting of benzene, toluene, xylene, methylcyclopentane, cyclohexane and mixtures thereof. Most preferably, the organic solvent is toluene.

In a preferred embodiment, the process comprises passing the

20 aqueous medium leaving the cyclohexanone oxime synthesis zone to a hydroxylammonium synthesis zone, and from the hydroxylammonium synthesis zone back to the cyclohexanone oxime synthesis zone. In the hydroxylammonium synthesis zone hydroxylammonium may be formed by catalytic reduction of nitrate or nitrogen oxide with hydrogen. Preferably, the catalyst is a palladium containing catalyst, for

25 instance a palladium or a palladium-platinum catalyst, present on a support, such as for instance carbon or alumina support.

In a preferred embodiment, the process comprises separating, by stripping, organic solvent, cyclohexanone, and/or cyclohexanone oxime, from the aqueous medium leaving the cyclohexanone oxime synthesis zone. Preferably, said

30 stripping is carried out prior to recycling the aqueous medium to a hydroxylammonium synthesis zone. This has the advantage that poisoning of the catalyst in a hydroxylammonium is avoided or minimized. The stripping process described in US-A-3,940,442 may for instance be used. It is preferred that the sum concentration of cyclohexanone and cyclohexanone in the aqueous medium entering the

35 hydroxylammonium synthesis zone is not more than 0.02 wt.% (200 ppm), more

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preferably not more than 0.006 wt.%, in particular not more than 0.002 wt.%, more in particular not more than 0.001 wt.% and most preferably not more than 0.0002 wt.% (relative to the weight of the aqueous medium). The stripping may also include separation of water from the aqueous medium. Preferably, the separated organic solvent, cyclohexanone and/or cyclohexanone oxime to the cyclohexanone oxime synthesis zone are recycled to the cyclohexanone oxime synthesis zone.

Preferably, the process is a continuous process.

A preferred embodiment of the process according to the invention is schematically illustrated in figure 1. In this embodiment, the cyclohexanone oxime synthesis zone comprises a first contact zone (I), and a second contact zone (II). In the cyclohexanone oxime synthesis zone an aqueous medium containing hydroxylammonium in water is countercurrently contacted with an organic medium comprising cyclohexanone and organic solvent. The aqueous medium and organic medium in the cyclohexanone oxime synthesis zone are represented by lines (1) and (2) respectively. The aqueous medium is supplied to the first contact zone (I) of the cyclohexanone oxime synthesis zone via line (3) and is discharged from the second contact zone (II) of the cyclohexanone oxime synthesis zone via line (4). At feeding level for organic solvent (S), organic solvent is fed into the cyclohexanone oxime synthesis zone via line (5). At feeding level for cyclohexanone (C), a stream of cyclohexanone is fed into the cyclohexanone oxime synthesis zone via line (6). The feeding level for cyclohexanone (C) is downstream of the feeding level for organic solvent (S), seen in the direction of flow of the organic medium. In the cyclohexanone oxime synthesis zone, cyclohexanone reacts with hydroxylammonium to form cyclohexanone oxime. An organic product solution comprising cyclohexanone oxime and cyclohexanone dissolved in organic solvent is discharged from the cyclohexanone oxime synthesis zone via line (7) at discharge level for organic product solution (P). The organic product solution is, preferably after having been washed with water or an aqueous solution, fed to distillation column (III). In distillation column (III) the organic solution is distilled to obtain the first product comprising organic solvent as a distillate. The first product is fed to the cyclohexanone oxime synthesis zone at the feeding level for organic solvent (S). The remaining bottom product comprising cyclohexanone oxime, cyclohexanone, and organic solvent leaves the first distillation column via line (8), and is fed to the top of distillation column (IV). In distillation column (IV), the second product comprising cyclohexanone is obtained as a distillate and the third product comprising cyclohexanone oxime is obtained as a bottom product. The third product

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leaves distillation column (IV) via line (9). The second product leaves the distillation column (IV) via line (10), and is fed into the cyclohexanone oxime synthesis zone.

The following specific examples are to be construed as merely illustrative, and not limitative, of the remainder of the disclosure.

EXAMPLES

Example I

This example is carried out using the set-up as illustrated in figure 1. The cyclohexanone oxime synthesis zone is formed by two pulsed packed columns (PPC's), the first PPC having a diameter of 1200 mm and a height of 13200 mm, the second PPC having a diameter of 1075 mm and a height of 11000 mm. The first PPC is operated at a temperature of 50 °C. The second PPC is operated at a temperature of 70 °C. An aqueous medium (hydroxylammonium = 1.6 mol/l, H^+ = 0.7 mol/l ($pH = 1.9$), $H_2PO_4^-$ = 3.9 mol/l, NH_4^+ = 3.0 mol/l, NO_3^- = 1.4 mol/l) is fed to the top of the first PPC (via line 3), the flow rate being 23 m³ per hour. To the bottom of the first PPC were fed cyclohexanone as well as the organic medium leaving the second PPC. The organic product solution leaving the top of the first PPC (via line 7) is washed and fed to a first distillation column (packed column having a stripping section and a rectifying section). In the first distillation column, the pressure in the top is 0.16 bar. Toluene having 99.9 wt. % purity leaves the top of the first distillation column. Toluene leaving the top of the first distillation column is recycled to the bottom of the second PPC. The bottom product of the first distillation column is fed to the top of a second column (packed column). The pressure in the top of the second distillation column is 0.12 bar. Cyclohexanone oxime leaves the bottom of the second distillation column. The top product (for composition see table 1) of the second distillation column is fed to the bottom of the second PPC. The sum concentration of cyclohexanone oxime and cyclohexanone in the aqueous medium leaving the bottom of the second PPC is 13000 ppm.

Example II

Example I is repeated with the difference that the top product of the second distillation column is fed to the middle (50% of the height) of the second PPC (position E2 in fig. 1). The sum concentration of cyclohexanone oxime and cyclohexanone in the aqueous medium leaving the bottom of the second PPC is 4300

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ppm. This examples shows that feeding the top product (second product) downstream of the level where the organic solvent is fed into the cyclohexanone oxime synthesis zone results in a decrease of the sum concentration of cyclohexanone and cyclohexanone oxim in the aqueous medium leaving the cyclohexanone oxime synthesis zone.

Example III

Example I is repeated with the difference that the top product of the second distillation column is, like the cyclohexanone, fed to the bottom of the first PPC (position E3 in fig. 1). The sum concentration of cyclohexanone oxime and cyclohexanone in the aqueous medium leaving the bottom of the second PPC is 800 ppm. This example shows that feeding the top product (second product) to the cyclohexanone oxime synthesis zone at the same level as cyclohexanone, results in a further decrease of the sum concentration of cyclohexanone and cyclohexanone oxim in the aqueous medium leaving the cyclohexanone oxime synthesis zone.

Example IV

Example I is repeated with the difference that the top product of the second distillation column into the first PPC at 20% of the height of the column (position E4 in fig. 1). The sum concentration of cyclohexanone oxime and cyclohexanone in the aqueous medium leaving the bottom of the second PPC is 180 ppm. This example shows that feeding the top product (second product) to the cyclohexanone oxime synthesis zone downstream of the level where cyclohexanone is fed to the cyclohexanone oxime synthesis zone, results in a further decrease of the sum concentration of cyclohexanone and cyclohexanone oxim in the aqueous medium leaving the cyclohexanone oxime synthesis zone.

Example V

Example I is repeated with the difference that the top product of the second distillation column into the first PPC at 50% of the height of the column (position E5 in fig. 1).

The sum concentration of cyclohexanone oxime and cyclohexanone in the aqueous medium leaving the bottom of the second PPC is 60 ppm. This example shows that feeding the top product (second product) further downstream results in a

further decrease of the sum concentration of cyclohexanone and cyclohexanone oxim in the aqueous medium leaving the cyclohexanone oxime synthesis zone.

Example VI

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Example I is repeated with the difference that the top product of the second distillation column into the first PPC at 80% of the height of the column (position E6 in fig. 1). The sum concentration of cyclohexanone oxime and cyclohexanone in the aqueous medium leaving the bottom of the second PPC is 45 ppm. This example shows that feeding the top product (second product) further downstream results in a further decrease of the sum concentration of cyclohexanone and cyclohexanone oxim in the aqueous medium leaving the cyclohexanone oxime synthesis zone.

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Table 1. overview of examples I to VI

	ex. I	ex. II	ex. III	ex. IV	ex. V	ex. VI
cyclohexanone						
- flow rate (10^3 kg/hr)	3.5	3.3	3.4	3.5	3.6	3.6
product solution						
flow rate (10^3 kg/hr)	12.2	12.2	12.9	13.3	13.6	13.9
anone conc. (wt.%)	1.4	1.1	1.1	1.2	1.5	1.9
oxime conc. (wt.%)	35.0	35.0	35.0	34.9	35.0	34.0
toluene con. (wt.%)	63.6	63.9	63.9	63.9	63.5	64.1
second product						
flow rate (10^3 kg/hr)	2.5	2.6	3.0	3.3	3.4	3.7
anone conc. (wt.%)	5.3	5.3	4.8	4.7	5.97. 5	6.8
oxime conc. (wt.%)	22.8	22.6	19.3	17.8	16.6	15.4
toluene con. (wt.%)	71.9	72.1	75.9	77.5	77.5	77.8
aqueous medium						
anone + oxime (ppm)	13000	4300	800	180	60	45

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CLAIMS

1. Process for treating an organic solution comprising cyclohexanone oxime, cyclohexanone and an organic solvent, said process comprising:
5 distilling the organic solution to obtain (i) a first product comprising organic solvent, (ii) a second product comprising cyclohexanone and (iii) a third product comprising cyclohexanone oxime; and feeding the second product to a cyclohexanone oxime synthesis zone in which hydroxylammonium is reacted with cyclohexanone to form cyclohexanone
10 oxime.
2. Process for treating a second product comprising cyclohexanone and cyclohexanone oxime, said process comprising:
in a hydroxylammonium synthesis zone, countercurrently contacting an aqueous medium with an organic medium, said aqueous medium containing
15 hydroxylammonium, said organic medium comprising organic solvent and cyclohexanone, to form cyclohexanone oxime; feeding organic solvent into said cyclohexanone oxime synthesis zone at a feeding level for organic solvent; and feeding said second product into said cyclohexanone oxime synthesis zone at
20 a level downstream of the feeding level for organic solvent (seen in the direction of flow of the organic medium).
3. Process according to claim 1, wherein the process comprises:
countercurrently contacting an aqueous medium with an organic medium in said cyclohexanone oxime synthesis zone, said aqueous medium containing
25 hydroxylammonium, said organic medium comprising organic solvent and cyclohexanone; feeding organic solvent into said cyclohexanone oxime synthesis zone at a feeding level for organic solvent; and feeding said second product into said cyclohexanone oxime synthesis zone at
30 a level downstream of the feeding level for organic solvent (seen in the direction of flow of the organic medium).
4. Process according to claim 2 or claim 3, wherein the process comprises:
feeding cyclohexanone into the cyclohexanone oxime synthesis zone at a feeding level for cyclohexanone, said feeding level for cyclohexanone being
35 downstream of the feeding level for organic solvent (seen in the direction of

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flow of the organic medium); and

feeding the second product into the cyclohexanone oxime synthesis zone at the feeding level for cyclohexanone or downstream of the feeding level for cyclohexanone (seen in the direction of flow of the organic medium).

5 6. Process according to any one of claims 2 to 4, wherein the process comprises:

10 discharging an organic product solution which comprises cyclohexanone oxime and organic solvent from said cyclohexanone oxime synthesis zone at a discharge level for organic product solution, said discharge level for organic product solution being downstream of the feeding level for cyclohexanone (seen in the direction of flow of the organic medium).

6 Process according to claim 5, wherein the process comprises feeding the second product upstream of the discharge level for organic product solution, (seen in the direction of flow of the organic medium).

15 7. Process according to claim 5 or claim 6, wherein the aqueous medium and organic medium present between the feeding level for cyclohexanone and the discharge level for organic product solution have a sum volume of V , and wherein the process comprises:

20 feeding the second product into the cyclohexanone oxime synthesis zone at a level such that the aqueous medium and the organic medium present between the feeding level for cyclohexanone and the level at which the second product is fed into cyclohexanone oxime synthesis zone have a sum volume of at least $V/10$.

25 8. Process according to claim 7, wherein the process comprises feeding the second product into the cyclohexanone oxime synthesis zone at a level such that the aqueous medium and the organic medium present between the feeding level for cyclohexanone and the level at which the second product is fed into cyclohexanone oxime synthesis zone have a sum volume of less than $9 \cdot V/10$.

30 9. Process according to any one of claims 5 to 8, wherein the process comprises:

35 countercurrently contacting the aqueous medium and the organic medium present between the feeding level for cyclohexanone and discharge level for organic product solution in a column or in series-connected columns, said column or said series-connected columns having a total column length L ; and

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- feeding the second product into said column or series-connected columns at a distance of at least $L/10$ measured from said feeding level for cyclohexanone.
10. Process according to claim 9, wherein the process comprises feeding the second product into said column or series-connected columns at a distance of less than $9 \cdot L/10$ measured from the feeding level for cyclohexanone.
- 5 11. Process according to any one of claims 5 to 8, wherein the process comprises countercurrently contacting the aqueous medium and the organic medium present between the feeding level for cyclohexanone and discharge level for organic product solution in a number (m) of series-connected mixer-settlers; and
- 10 feeding the second product into to the second or higher-numbered mixer-settler counted from the feeding level for cyclohexanone.
12. Process according to claim 11, wherein the process comprises feeding the second product to the m, m-1, or lower-numbered mixer-settler, counted from the feeding level for cyclohexanone.
- 15 13. Process according to any one of claims 2 to 12, wherein the process comprises feeding the second product into the cyclohexanone oxime synthesis zone such that the sum concentration of cyclohexanone and cyclohexanone oxime in the aqueous medium leaving the cyclohexanone oxime synthesis zone is less than 20,000 ppm (2 wt.%), preferably less than 5,000 ppm (0.5 wt.%), more preferably less than 1,000 ppm (0.1 wt.%), more preferably less than 500 ppm (0.05 wt.%), more preferably less than 200 ppm (0.02 wt.%).
- 20 14. Process according to any one of claims 1 to 13, wherein the process comprises withdrawing said organic solution from a cyclohexanone oxime synthesis zone, preferably from the cyclohexanone oxime synthesis zone.
- 25 15. Process according to any one of claims 1 to 14, wherein the organic solution contains cyclohexanone oxime.
16. Process according to any one of claims 1 to 15, wherein the weight ratio cyclohexanone oxime/cyclohexanone in the second product is higher than 0.1, preferably higher than 0.2, more preferably higher than 0.3, in particular higher than 0.4, more in particular higher than 0.5.
- 30 17. Process according to any one of claims 1 to 16, wherein the process comprises distilling the organic solution to obtain the first product as a distillate; distilling the remaining bottom product to obtain the second product
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as a distillate and the third product as a bottom product.

18. Process according to any one of claims 1 to 17, wherein the process comprises feeding the first product into the cyclohexanone oxime synthesis zone.
- 5 19. Process according to claim 18, wherein said feeding of organic solvent into the cyclohexanone oxime synthesis zone at the feeding level for organic solvent is effected by feeding the first product into the cyclohexanone oxime synthesis zone at the feeding level for organic solvent.
- 10 20. Process according to any one of claims 1 to 19, wherein the ratio $f_h/f_o < 1.00$, more preferably < 0.99 , more preferably less than 0.98, wherein f_h represents the molar quantity of hydroxylammonium fed to the cyclohexanone oxime synthesis zone per unit of time (in mol/s), and f_o represents the molar quantity of cyclohexanone fed to the cyclohexanone oxime synthesis zone per unit of time (in mol/s).
- 15 21. Process according to any one of claims 1 to 20, wherein the organic solvent is selected from the group consisting of benzene, toluene, xylene, methylcyclopentane, cyclohexane and mixtures thereof.
22. Process according to claim 21, wherein the organic solvent is toluene.
- 20 23. Process according to any one of claims 1 to 22, wherein the aqueous medium is an acidic, medium buffered with phosphate.

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ABSTRACT

The invention relates to a process for treating an organic solution comprising cyclohexanone oxime, cyclohexanone and an organic solvent, said process comprising distilling the organic solution such as to obtain (i) a first product comprising organic solvent, (ii) a second product comprising cyclohexanone and (iii) a third product comprising cyclohexanone oxime; and feeding the second product to a cyclohexanone oxime synthesis zone in which hydroxylammonium is reacted with cyclohexanone to form cyclohexanone oxime.

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